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DLA-94-P30005

# HAZARDOUS MATERIAL STOCKAGE POLICY ANALYSIS

OCTOBER 1993



FOR

DEPARTMENT OF DEFENSE
DEFENSE LOGISTICS AGENCY
DEPUTY DIRECTOR (MATERIEL MANAGEMENT)
CAMERON STATION
ALEXANDRIA, VA 22304-6100



*INSIGHT THROUGHT ANALYSIS*

DORO CORPORATE RESEARCH

DLA-94-P30005

# HAZARDOUS MATERIAL STOCKAGE POLICY ANALYSIS

October 1993

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## FOREWORD

This study was requested by the Deputy Director, Material Management, Defense Logistics Agency (DLA), to determine which of two stock location policies DLA should use in positioning hazardous material (HM) stocks. This effort is a response to Defense Management Review Decision (DMRD) 901 which directs DLA to reduce supply system costs, DMRD 902 pertaining to consolidation of DLA depots, and lastly to recent studies (and in particular the Stock Location Policy Analysis, DLA-92-P10148) which were directed to the same ends. We are indebted to DLA's Material Management, Supply Management and Depot Operations Divisions, the Defense General Supply Center's Department of Defense Hazardous Material Data Bank Branch, and three HM depots, Ogden, Memphis and Richmond. These organizations provided generous amounts of their time and expertise.

CHRISTINE L. GALLO
Executive Director
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# EXECUTIVE SUMMARY

Previous research into stock location policy has indicated that demand for DLA's fast moving stock was relatively unstable. This focused attention on DLA's long standing stock location policy of placing stock at depots nearest to the ordering customer. The results of previous research showed that for fast moving items DLA could realize large savings by changing to a closest to vendor stock location policy. The focus for this study was to answer the same question only for hazardous material. Futhermore, the stockage locations were to be restricted to the three main hazardous facilities at Defense Depot Richmond, Virginia (DDRV), Defense Depot Ogden, Utah (DDOU), and Defense Depot Memphis, Tennessee (DDMT). This choice was made to hopefully avoid incurring the expense of maintaining hazardous material storage facilities at additional sites. Cost was not to be the only critical factor. The capability of a depot to store and handle hazardous material was also taken into consideration in this comparative analysis.

The results of this study are that the closest to vendor stock location policy is significantly less expensive, approximately $4.2 million per year. It was found that the three hazardous depots of DDRV, DDOU, and DDMT could easily manage increased throughput limits. However, it was found that while the depots' space surplus and shortage conditions in specific hazardous categories net out to a slight surplus of space, critical space shortages exist for certain hazardous classes both at specific depots and for the system as a whole. The two hazardous classes with the most critical space shortages are the flammable and corrosive classes. Without resolution of these shortage issues, the policy cannot be implemented.

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# SECTION 1
# INTRODUCTION

## 1.1 BACKGROUND

As a result of Defense Management Report Decision (DMRD) 901 - Reducing Supply System Costs, and DMRD 902 - Supply Depot Consolidation, DLA management initiated several actions to effect the changes specified in the DMRDs. A number of studies were conducted by the DLA Operations Research Office (DORO) in support of these DMRDs. One study, the Stockage Location Policy Analysis, DLA-92-P10148, examined several alternative stockage policies. The conclusion of that study was that in view of the geographical instability of much of the demand from time period to time period, a closest to vendor stockage policy should be implemented as a general policy. However, exceptions were allowed to the general policy if the exceptions made economic sense.

In view of the specialized storage requirements for hazardous material and the limited number of depot sites with that capability, a natural question was whether an exception should be made for these items. Perhaps the demand for hazardous items was stable enough to warrant using the closest to customer policy. There was also concern that under a closest to vendor policy one of the hazardous sites would greatly exceed storage capacity if the vendors were concentrated in a geographic area. DORO was asked to assist in examining these issues and in determining the least expensive of the two policies for DLA hazardous items.

## 1.2 STOCK LOCATION POLICIES

The two stock location policies considered are the closest to vendor and the closest to customer. A stock location policy, in this study, simply means on what basis a decision is made on where a vendor is to deliver stock.

When a closest to vendor policy is in effect and a purchase is generated for a hazardous item, that buy is sent to the DLA hazardous depot located the least number of miles away from the vendor. However, this does not necessarily mean a specific item will always be stocked at the same site. Throughout time, as the vendor receiving contract awards may vary, the depot receiving the buy may also vary.

At the opposite end of the stock policy spectrum is the closest to customer. In this situation, stock shipped by the vendor is delivered to perhaps several hazardous depots. The buy quantity would be split in proportion to the customer demands for the various regions supported by the depots. One immediately recognized difference between the two policies is in the number

of miles new stock travels between the vendor and the receiving depot and between the receiving depot and the customers. This and other policy characteristics are discussed later.

## 1.3 SCOPE

As part of the depot consolidation effort, the primary distribution site (PDS) concept needed to be applied to hazardous storage. Although hazardous stock is currently located at many of the 30 DoD depot sites, only three depots with large hazardous storage facilities would be stocking depots. These depots are Defense Depot Richmond, Virginia (DDRV), Defense Depot Memphis, Tennessee (DDMT), and Defense Depot Ogden, Utah (DDOU).

Military Service managed hazardous items are excluded from the study.

Total stockage policy costs are considered to be composed of first and second destination transportation expenses and depot receipt costs. Issue costs are excluded from the analysis because the number of issues remains constant under either policy.

Five modes of transportation are used for second destination shipping (air small parcel, air freight, surface parcel, less than a truckload (LTL) and truckload (TL)). Only the LTL and TL shipment classes are used for first destination shipments.

The study uses the fiscal years 1988, 1989 and 1990 as the historical data base for hazardous transactions, namely depot receipts from vendors and issues to depot customers. This time period was used because for the most part it excludes the Desert Storm/Shield impact.

A 25 percent drawdown factor will be used to reduce the historical workload to simulate the overall reduction in DoD force strength through fiscal year 1995. This factor affects the quantity shipped and not the actual number of receipts or issues made over the historical time frame.

A 25 percent reduction in hazardous assets will be used to reflect the effects of the inventory reduction initiatives.

## 1.4 OBJECTIVES

The overall objective of the study is to determine which stock location policy, closest to vendor or closest to customer, is the least expensive for DLA's hazardous items when stockage is restricted to the three primary hazardous sites.

A secondary objective is to calculate the impact on cost resulting from a relaxation to the three-site policy for

compressed gas cylinders, asbestos and radioactive items. Details on these exceptions will be presented later.

## SECTION 2
## GENERAL APPROACH

### 2.1 OVERVIEW OF METHODOLOGY

Since the main goal of the study is to identify the least expensive hazardous material stock location policy, we isolated the major costs involved. Then using historical data we calculated the transportation cost of each vendor shipment, the processing cost of each receipt, and the transportation cost of each issue. These costs were then summed over the 3 year time period for each of the two stock location policies under study. A 3 year time period was chosen to allow the effects of shifts in vendor locations and in demands to be incorporated into the analysis.

Costs, however, do not present the entire picture. Storage space and issue capability have to be considered. These areas caused major modifications to the model that had been used previously in the Stock Location Policy Analysis, DLA-92-P10148. This modified model was the central tool in this analysis. Since hazardous storage space is classified into several categories or classes based on the types of material that can be safely stored within the facility, the model needed to have the capability to calculate statistics on the utilization of space by hazardous class. This would reflect any potential problems in exceeding a site's capacity. Similarly, throughput statistics are captured to compare the number of issues with the site's capability.

#### 2.1.1 ON HAND BALANCES AND DEPOT AREAS

Since conforming storage space at a site is a definite constraint, it was necessary to incorporate a methodology for treating the inventory in the system at the start of a model run and its distribution among the three hazardous depots. The approach taken is based on the desire to represent the system in steady state, i.e. after these policies have been in effect for a period of time. Then the alternatives for this steady state could be costed out. Therefore, the distribution of assets should reflect the effect of these policies. For example, if the vendors for an item tended to always be in the northeast, then the assets would always be at DDRV under the closest to vendor policy. Under the closest to customer policy if 80 percent of the demand was in the west then 80 percent of the assets would be at DDOU.

To ensure proper distribution of on hand balance (OHB), several calculations were made. Both vendors and customers are grouped or "clustered" into the depot area which is closest to them. The

model determines, based on this clustering, how much demand for an item came from each of the three depot areas in the previous fiscal year (FY 1987). In the closest to vendor runs OHB is distributed to each of the three depots in direct proportion to the amount that would have been received in that area in the preceding year. For closest to customer runs, the OHB is distributed in accordance with last year's demand quantities for each region serviced by each depot.

### 2.1.2 ISSUE AND STORAGE LIMITS

The approach taken in modifying the model to accommodate storage and issue limits at a site was not to cause receipts or issues to be diverted to other sites but rather to collect statistics on how much these limits were exceeded. The only time issues are diverted is when a site is in an out-of-stock condition. In this out-of-stock case, issues which cannot be filled at the closest depot are directed to the next nearest depot. If the issue can find no depot able to fill the order, the order becomes a due out. When throughput capacity is reached at a depot all remaining issues arriving on that day are assumed to be filled in the next 8-hour shift on that day. Statistics are collected on the number of issues filled on the second shift. Receipts arriving at a depot which currently has no space available for its hazardous class are queued up at that site. Again, statistics are collected on any over or under utilization of space.

### 2.1.3 TRANSPORTATION COSTS

As each historical transaction (receipt or issue) is processed, the model calculates the transportation expense involved and stores that cost data to compute total transportation expense statistics at the end of the model run. Transportation expenses are a function of the shipment weight, the transportation mode used, and the miles that the shipment must travel. Guaranteed traffic rates are used to calculate both inbound and outbound transportation costs.

Determination of the number of receipts and size of receipts depended on the policy. Using the 3 year historical receipt file, those receipts which had the same contract number, same NSN and the same receipt date, plus or minus 10 days, were combined to represent a single buy. The vendor source of the material was the historical one. Under the closest-to-customer policy, this buy was split into receipts to each of the three depots. The quantities going to each depot were in proportion to the demand experienced for each region. Under closest to vendor this buy went to the single closest depot. The receipt size, its destination location, and its source location were then combined

with the transportation rates to yield an inbound cost for that transaction.

### 2.1.4 TOTAL DEPOT RECEIPT COSTS

Total depot receipt costs are computed using a $41.48 cost factor which is applied to each receipt at each depot. The factor is a generic average receipt (unit) cost for truckload and less than truck rate bulk, hazardous material shipments received system wide. This factor was provided by DLA's Office of Comptroller, Program/Budget Division. The total receipt cost computation is straightforward - multiplying the number of actual receipts handled by the depot times the cost factor.

As a final calculation, the three cost components for each policy are added together to form a total policy cost: first destination transportation cost + second destination transportation cost + receipt cost.

### 2.1.5 SPACE AVAILABILITY

Space availability is measured by the average capacity rate. This rate is calculated using the average monthly on hand cube and the cubic feet of conforming hazardous storage space available. The average capacity rate is calculated for each of the ten hazardous classes at each depot and is formulated as follows:

$$\text{Average Monthly Capacity Rate} = \frac{\text{Average Monthly Cube on Hand}}{\text{Cubic Feet of Conforming Space}}$$

Average monthly cube on hand, which includes stocks held in queue as well as in conforming storage, is calculated using a moving average over each day of the month. In addition to providing this monthly visibility, the model also provides an overall capacity rate by averaging these monthly values.

The average capacity rate can be any number greater than or equal to zero. For example, if average monthly cube on hand for the radioactive class is 10,000 cubic feet and total conforming space for this class is 5,000, then the average capacity rate is 2.0, i.e., twice the existing space is needed to store the stock normally on hand. If the figures were reversed, i.e., 5,000 cubic feet on hand and 10,000 cubic feet available, the capacity rate would be 0.5 meaning that excess storage space exists.

## 2.2 SOURCES OF DATA

### 2.2.1 SPACE AND THROUGHPUT CONSTRAINTS

A data call was made to DLA's three hazardous depots via DLA's Operations Support Office (DOSO) requesting the net cubic feet of attainable, conforming space available at their site for each of the ten hazardous classes. The net attainable cubic feet does not include aisle space. However, it does allow for additional storage aids if a facility is not fully utilized. Also in this data call was a request for the number of hazardous material issues that could be handled by each depot in an 8-hour shift. Note that this is a total issue capacity and is not segregated by hazardous class. The details of both the space and throughput constraints by site are given in Appendix A.

### 2.2.2 HAZARDOUS CHARACTERISTIC CODE (HCC) GROUPING

The hazardous characteristic codes are arranged in the following groups having the same or similar storage requirements. These determine the storage class for the item.

HAZARDOUS CODES BY STORAGE FACILITY

| Facility Type | Hazardous Characteristic Code(s) |
|---|---|
| A Radioactive | A1, A2, A3, A4 |
| C Corrosive | C1, C2, C3, C4, D4, J6 |
| D Oxidizer | D1, D2, J3 |
| E Explosive | E1, E2 |
| F Flammable | F1, F2, F3, F4, F6, F7, F8, J1, J2 |
| G Gas, Compressed | G1, G2, G3, G4, G5, G6, G7, G8, G9 |
| L Low Hazard | M1, J7, W1 |
| P Peroxide, Organic | P1, P2, J4 |
| R Reactive | R1, R2 |
| T Poison | T1, T2, T3, T4, T5, T6, T7, J5, K1, K2, D3, F5 |

*Table 2-1. Hazardous Codes By Storage Facility*

### 2.2.3 HCC HIERARCHY AND CONVERSION TABLES

The Defense General Supply Center (DGSC) Directorate of Technical Operations, DoD Hazardous Material Data Bank Branch (DGSC-SSH), supplied a master list identifying all DLA hazardous items. A conversion table and a hierarchal listing of HCCs from most to least dangerous (Appendix B) were also provided and were necessary because of the recent changes in HCC assignments and because some items have multiple HCC codes. Items appear with multiple codes because of differing chemical composition based on the particular manufacturer. In this case the item was assigned the most dangerous of all its codes.

### 2.2.4 HAZARDOUS MATERIAL RECEIPT, MRO AND ASSET INPUT

#### 2.2.4.1 Input Receipt Files

DORO's Defense Integrated Data Bank (DIDB) was used to construct the model's input files. Receipt data was collected from the construction, electronic, general, industrial, and medical commodities. The only commodities omitted were bulk fuels and the Defense Personnel Suppport Center's clothing, textiles and subsistence.

#### 2.2.4.2 Input Material Release Order File

This 1,148,379 record file was constructed from the DIDB's historical material release order (MRO) records for the same commodities discussed above. This file consists of the 12 fiscal quarters covering the first quarter of FY 1988 to the last quarter of FY 1990. Each MRO record contains the NSN, HCC, ship to DODAAC, zip code, routing identifier code of the shipping depot (RIC), quantity, and date shipped.

#### 2.2.4.3 Assets On-Hand File

This input file was also created from the DIDB files. Records were obtained from this file for each item indicating the depot where the stock is located and the actual quantity of stock on hand at a given time. The model is started with stock on hand as of the last quarter of fiscal year 1987 since this time period immediately precedes the project test period. The beginning OHB is distributed as discussed previously.

# SECTION 3
# ANALYSIS

## 3.1 INITIAL ANALYSIS

In this section the initial results of comparing the closest to customer to the closest to vendor policies, as defined previously, will be presented. The sections following, beginning with section 3.2, discuss several additional alternative policies that were examined and several sensitivity analyses that were conducted.

Before discussing costs and operational statistics, however, some general information is provided. Recall that both policies are treated identically with respect to a 25 percent reduction in issues due to force draw down and an initial on hand balance reduction of 25 percent to reflect inventory reduction initiatives. The total number of hazardous items DLA ever managed (both inactive and active) up to the 4th quarter of fiscal year 1990 equals 10,397. Of this number 31 percent (3,260) experienced no activity over the time period FY 88 quarter 1 to FY 90 quarter 4. On hand balance of hazardous material in cubic feet at all depots at FY 87 4th quarter was 5.9 million cubic feet.

### 3.1.1 COST RESULTS

Inbound transportation costs are those costs incurred in transporting goods from a vendor to a DLA depot. The basic premise of the two stockage policies leads to the expectation that significant differences will exist in this cost category. These costs (Table 3-1) represent a cumulative cost over 3 years.

| INBOUND COSTS, FY 88-90<br>First Destination Transportation Expense | |
|---|---|
| Closest to Vendor Policy | $13,151,019 |
| Closest to Customer Policy | $28,081,703 |
| Difference (Customer - Vendor) | $14,930,684 |

*Table 3-1. Inbound Costs*

Inbound costs for the closest to vendor policy amount to about $13.2 million as compared to a closest to customer inbound expense of about $28.1 million. The $14.9 million difference is due to the fact that under the vendor policy the materials are travelling less distance and in larger shipments. In comparison under the customer policy the vendor must transport the materials, usually in smaller shipments, to the depot locations which are nearest to the customer. This may be, and often is, many times further away than the depot closest to the vendor.

On the other hand, the closest to customer policy has an apparent advantage when the outbound costs are considered. Under the closest to customer policy, the customer who ordered the stock should receive it from the depot which is closest. This being the case, it is anticipated that outbound costs will be lower under the customer policy than they are under the vendor policy.

However, there are several dynamic factors that complicate the issue. If a depot is out of stock, then the issue will not be made from the closest site. How often this occurs depends to a great extent on how much demands fluctuate over time. The amount bought into a depot is based on the last time period's demand which may be an inadequate predictor of the future.

Another factor influencing second destination costs relates to the on hand balance at the beginning of the model run. This factor probably has a greater effect for the closest to vendor policy. If the geographic location of the vendor shifts throughout time, assets will be spread throughout the system. If the item is in long supply then significant quantities will be at all three sites. This results in issues being supplied by a depot close to the customer even under a closest to vendor policy. How these factors all combine to influence second destination cost is summarized in Table 3-2.

OUTBOUND COSTS, FY 88-90
Second Destination Transportation Expense

| | |
|---|---|
| Closest to Vendor Policy | $39,403,237 |
| Closest to Customer Policy | $35,844,563 |
| Difference (Customer - Vendor) | ($ 3,558,674) |

*Table 3-2. Outbound Costs*

Second destination transportation expenses of $35.8 million are approximately $3.6 million less under the customer policy than under the vendor policy with outbound costs of $39.4 million.

The final cost to consider is the receipt processing cost. The fact that the closest to vendor policy forces a buy to always go to a single site yields a cost reduction over the closest to customer policy. Under the latter policy, buys are received in two or three locations based on the demand in the various regions supported by the site. Thus (see Table 3-3) the difference in the number of receipts for the 3 years is approximately 19 thousand under the closest to vendor policy versus approximately 50 thousand for the closest to customer policy. The net cost difference over the 3 years was approximately 1.2 million dollars.

RECEIPT COSTS, FY 88-90

| | | | | |
|---|---|---|---|---|
| Receipt Costs for Closest to Vendor Policy: | | | | |
| 19,153 | * | $41.48 | = | $ 794,466 |
| Receipt Costs for Closest to Customer Policy: | | | | |
| 50,355 | * | $41.48 | = | $2,088,725 |
| Difference (Customer - Vendor) | | | = | $1,294,259 |

*Table 3-3. Receipt Costs*

Total policy costs (see Table 3-4) contain three costs; they are inbound and outbound transportation costs, and receipt costs.

TOTAL POLICY COSTS, FY 88-90

| | Vendor | Customer |
|---|---|---|
| Inbound Costs | $13,151,019 | $28,081,703 |
| Outbound Costs | $39,403,237 | $35,844,563 |
| Receipt Costs | $ 794,466 | $ 2,088,725 |
| Total Policy Cost | $53,348,722 | $66,014,991 |
| Difference (Customer - Vendor) | $12,666,269 | |

*Table 3-4. Total Policy Costs*

The closest to vendor total policy cost equals about $53.3 million, where as the closest to customer total policy cost is approximately $66.0 million. Therefore, from a cost standpoint the vendor stock location policy is the least cost policy bettering the customer policy and saving DLA $12.7 million over the study time span. Translated into a yearly difference, this becomes approximately $4.2 million.

### 3.1.2 OPERATIONAL RESULTS

Although the closest to vendor policy is the least costly of the two, the capability of the system to accommodate this policy still needs to be addressed. Furthermore, whether either policy is feasible under the assumption of moving to a three site restriction is also an open question. The operational statistics of average capacity rate and daily throughput will provide some insights to these issues. These statistics are presented in Table 3-5. Shortages in space are indicated by negative numbers which are enclosed in parentheses.

A COMPARISON OF CUBIC FEET SURPLUS AND SHORTAGE

| CLASS | VENDOR | CUSTOMER |
|---|---|---|
| RADIOACTIVE | (80,962) | (76,055) |
| CORROSIVE | (1,216,693) | (1,276,540) |
| OXIDIZER | 216,709 | 218,024 |
| EXPLOSIVE | 3,224 | 3,221 |
| FLAMMABLE | (1,691,057) | (1,720,371) |
| COMPRESSED GAS | 884,008 | 884,348 |
| LOW HAZARD | 2,660,381 | 2,656,924 |
| PEROXIDE | 44,024 | 40,230 |
| REACTIVE | (60,665) | (60,131) |
| POISON | (228,346) | (248,253) |
| TOTAL | 530,623 | 421,399 |

*Table 3-5. Storage Space Net Results*

System wide, five of the ten storage facility types had excess space and five had a space shortage. This condition exists under either policy. Also, the specific classes over and under remained the same under both policies. In descending order of space shortage the classes of hazardous are: Flammable, Corrosives, Poisons, Radioactive and Reactives. Under the vendor policy the total number of cubic space for categories experiencing shortages is about 3.3 million compared to a figure of 3.4 million under the customer policy.

In terms of categories having excess space the two policies are about equal at 3.8 million in excess cube. When the short and excess cube are summed for each policy the vendor has a net excess of 530 thousand cubic feet while the customer has a 421 thousand foot excess. A detailed analysis of the shortfalls and excesses at each of the three sites is provided for the closest to vendor policy in Appendix C. For the current analysis, the 50 percent column in Appendix C should be used. Explanation of this will be provided in Section 3.4.2.

The other operational factor to consider is the issue workload. A depot's throughput limit is determined by the number of MROs or lines it can process in one 8-hour shift. Each depot has a unique blend of material handling equipment; therefore, each depot has a unique throughput capacity level. The Ogden depot can handle up to 300 lines per 8-hour shift while Memphis and Richmond can handle up to 325 and 475 lines respectively. How close to these limits the workload came is presented in Table 3-6.

ISSUE WORKLOAD RESULTS

| DISTRIBUTION SITE | DAILY ISSUE CAPACITY | HISTORICAL ISSUE RATE | VENDOR ISSUE RATE | CUSTOMER ISSUE RATE |
|---|---|---|---|---|
| OGDEN | 300 | 266 | 297 | 305 |
| MEMPHIS | 325 | 337 | 331 | 324 |
| RICHMOND | 475 | 368 | 479 | 478 |
| TOTAL | 1,100 | 971 | 1,107 | 1,107 |

*Table 3-6. Issue Workload Results*

Throughput analysis at each depot under a closest to vendor policy shows that Ogden will average 297.5 lines per day, Memphis will process 331.4 lines per day and Richmond will have 479.5 lines throughput on average per day. In other words, Ogden is 2.5 lines under their limit while Memphis and Richmond are 6.4 lines and 4.5 lines over their limit on an average day. On a system wide basis the average daily MROs exceed the limit by 8.5 lines. The customer policy daily average lines exceed the limit by 8.4 lines. On a system basis this is approximately .7 percent which is insignificant especially in view of the fact that the capabilities are estimates. The same is essentially true on a site basis although the percentage over for DDMT and DDRV are approximately 2 percent and 1 percent.

## 3.2 SINGLE SITE CLOSEST TO CUSTOMER POLICY

During the 9 April 1993 briefing the client asked for an evaluation of a revision to the closest to customer policy. Under this revision, a buy would be sent to the single site having the largest demand in its region instead of splitting the buy to the sites in proportion to their demand. The main idea was to reduce inbound costs as the closest to vendor policy does but still retain some of the closeness to the customer. Under this revised policy, the model determines for each NSN what depot area has the largest demand. All buys for this NSN are sent to that depot area for the course of a model year at which time annual demand is recalculated and the process continues.

The impact of the single site stocking under the closest to customer is that total customer policy costs are increased by $1.0 million over the 3-year period. This is the net effect of a decrease in first destination transportation expense of approximately $6.0 million and an increase in outbound costs of $7.0 million. The total customer policy cost under the single site case goes from $66 to $67 million. Single site stocking results in most stock being placed in the east and west depot areas. This combines with significant central area demand for the stock which depletes central region stock and ultimately forces cross region shipments to increase.

To carry the analysis one step further, the single site case was again modified so that instead of all stock of a given NSN going to the depot area with the largest historical demand, the criteria was tightened so that a single depot would receive all stocks only if their historical demand was equal or greater than 50 percent. If no area had 50 percent or more of the historical demand, the stock was sent to each depot according to their demand proportion as is done in the original policy. This policy alteration decreased total customer policy cost by about $3.0 million, the net effect of a $4.0 million decrease in first destination transportation expenses and a $1.0 million increase

in outbound costs. However, when compared to the closest to vendor policy the difference is still approximately $8 million in favor of the closest to vendor.

## 3.3 MODIFICATIONS OF THREE SITE RESTRICTION

The changes discussed in this section are unlike those in the previous in that they focus on individual storage classes or on specific hazardous compatibility codes and where items in that category are allowed to be stored. The client requested examination of modifications for three different classes. In two cases, storage sites other than Ogden, Memphis, and Richmond are allowed. In the analysis changes were made to accommodate one class at a time to isolate the effects of that change. Furthermore, although the modifications were made both to the closest to customer and closest to vendor policies, the effects of the changes were essentially the same in both, so only the findings for closest to vendor will be presented.

### 3.3.1 DEFINITION OF MODIFICATIONS

The first modification limits storage of compressed gas cylinders (HCC G1 - G9) to Ogden and Richmond. All three depots currently have existing storage space and stocks of this material.

The second modification brings a new depot, New Cumberland, PA, into the hazardous depot configuration. For items with HCC T6 - asbestos, a health hazard classification, the only allowable sites are New Cumberland and DDOU. New Cumberland can store only this class.

The last modification uses the Tracy, CA, and New Cumberland, PA, depot locations for all radioactive hazardous material stock (HCC A1 - A4). Neither Tracy nor New Cumberland may store any other classes of hazardous.

### 3.3.2 COST RESULTS

Costs relative to first and second destination transportation expenses and the expense of receiving at the storage depots are identified for each of the three modifications and compared to the base case, i.e. closest to vendor without these modifications, in Table 3-7. The most expensive ($53.8 million) was the compressed gas change while the least expensive was the asbestos ($50.8 million) which saved $3 million over the 3 years when compared against the base. Between the high and low are the base case and radioactive exceptions with total policy costs of $53.4 and $50.9 million respectively. The main reason that the compressed gas modification becomes so expensive, relative to the others, is that Ogden's number of cross region shipments increase from 1,491 in the base case to 1,679 for compressed gas cylinders. Increased transportation miles result in increased outbound costs.

SITE MODIFICATION COST RESULTS
( IN MILLIONS OF DOLLARS)

| | | MODIFICATION | | |
|---|---|---|---|---|
| | BASE | COMPRESSED GAS | ASBESTOS | RADIOACTIVE |
| INBOUND COSTS | 13.2 | 13.3 | 13.5 | 13.2 |
| OUTBOUND COSTS | 39.4 | 39.7 | 36.5 | 36.9 |
| RECEIPT COSTS | 0.8 | 0.8 | 0.8 | 0.8 |
| TOTAL COSTS | 53.4 | 53.8 | 50.8 | 50.9 |

*Table 3-7. Site Modification Cost Results*

### 3.3.3 SPACE AND THROUGHPUT CAPACITY RESULTS

In the compressed gas class for the base case, both Ogden and Richmond have excess space but Memphis has a capacity rate of about 1.5 indicating that they need half again as much space as they currently have. This problem is alleviated by directing all former Memphis compressed gas to Ogden and Richmond. These two depots can absorb the increase without exceeding their capacity.

For the class containing asbestos, the poison class, the capacity rates under the base case are 0.51, 0.89 and 5.45 for Ogden, Memphis and Richmond, respectively. Diverting asbestos to Ogden and New Cumberland exclusively reduces the space shortage at Richmond for the poison class. Its capacity rate drops from 5.45 to 2.26. However, Ogden now exceeds its poison capacity with a rate of 3.08. Note that asbestos (T6) is but one of seven HCCs under the poison (T) class. There is no restriction on the other HCCs in this case.

Under the base case, Memphis is seen to be in a severe space shortage condition for radioactive materials with a capacity rate of 1,638.34. This rate is extremely high because Memphis only has 100 cubic feet available for radioactive materials. This problem can be eliminated, however, by securing an estimated 170,000 cubic feet of attainable, conforming storage. Space of this size will house all DLA radioactive stock. Storing radioactive stock exclusively at Tracy and New Cumberland

alleviates entirely the space shortage at Memphis. Tracy would need approximately 106,000 cubic feet available and New Cumberland approximately 64,000 to accommodate this class.

For all three modifications, there were no problems of exceeding throughput capacity at any of the sites.

## 3.4 OTHER FINDINGS

### 3.4.1 COSTS BY HAZARDOUS CLASS

An analysis was made of total transportation costs by class to see if there are any particular classes of hazardous material for which a closest to customer policy may be more cost effective. The results indicate that closest to customer is only less expensive for the reactive class and only slightly more expensive for the explosive class. The cost differences between the policies for these classes are insignificant.

### 3.4.2 SPACE REQUIREMENT SENSITIVITY ANALYSIS

The preceding analyses relied on some basic calculations for the space required to store stock under a new policy. Using the quantity of an item on hand and the cubic feet of a unit of that item, the minimum physical space to hold that item is calculated and referred to as stock cube. However, additional space must be allotted to the storage of that item because of several factors. For example, the warehouseman must have space to gain access to the items. Storage locations are often dedicated to a single item so that even though there is only a single 1 cubic foot item in a 5 cubic foot location, additional items will not be stored in that same location, nor will that item be rewarehoused to a smaller location. Past analysis has indicated that generally in order to accommodate these factors, the stock cube must be multiplied by 2 to obtain the storage cube required.

The method used within the model to accommodate this stock to storage cube ratio of 1:2 was to perform stock on hand calculations in terms of stock cube. But when comparing cube required to available capability, the cube available at a site was reduced to 50 percent of the value provided by DOSO.

This 50 percent factor was a general rule developed by taking an overall look at several sites as they have been historically managed. One could argue that the hazardous space is, or will be, better managed since it is an expensive, limited capability. For these reasons, a sensitivity analysis was peformed on the 50 percent factor. Instead of 50 percent of the net attainable cube being used as a capability limit, a 75 percent factor was used. This sensitivity analysis was only performed for the closest to vendor policy.

The impact of increasing the ability to store more stock in the same amount of space is significant when examining the space requirements from the system level as can be seen in Table 3-8. Although under both the 50 percent and 75 percent cases there is a net space surplus, the surplus increases from approximately 530 thousand cubic feet to 3.3 million in the 75 percent case. However, significant shortages and excess capabilities still remain for specific classes indicating an improper mix of hazardous capability for the system. The major imbalance on a system basis is between the flammable and low hazardous classes. The low hazard excess capability easily outweighs the shortage for flammables.

THE COMBINED HM DEPOTS
A COMPARISON OF STORAGE SPACE OVER/SHORT
AT 50 AND 75 PERCENT OF TOTAL SPACE

| HAZARDOUS STORAGE FACILITY | AVERAGE STOCK IN CUBIC FEET | TOTAL CUBIC FEET AVAILABLE | CUBIC FEET OVER/(SHORT) AT 50% | AT 75% |
|---|---|---|---|---|
| RADIOACTIVE | 84,266 | 6,608 | (80,962) | (79,310) |
| CORROSIVE | 1,879,949 | 1,326,512 | (1,216,693) | (885,065) |
| OXIDIZER | 48,455 | 530,327 | 216,709 | 349,290 |
| EXPLOSIVE | 30 | 6,508 | 3,224 | 4,851 |
| FLAMMABLE | 2,180,759 | 979,404 | (1,691,057) | (1,446,206) |
| COMPRESSED GAS | 371,221 | 2,510,458 | 884,008 | 1,511,623 |
| LOW HAZARD | 56,812 | 5,434,386 | 2,660,381 | 4,018,978 |
| PEROXIDE | 17,374 | 122,796 | 44,024 | 74,723 |
| REACTIVE | 107,703 | 94,077 | (60,665) | (37,145) |
| POISON | 410,444 | 364,196 | (228,346) | (137,297) |
| TOTAL | 5,157,013 | 11,375,272 | 530,623 | 3,374,441 |

*Table 3-8. Space Availability Sensitivity Results*

This system imbalance between these two classes is also reflected on a geographic basis. Statistics for individual sites are presented in Appendix C. These indicate that Richmond has a large shortfall in overall capability with a large portion of the shortfall occuring in the flammable class. On the other hand, Ogden has significant excess capability overall with most of that occuring in the low hazard class.

## SECTION 4
## CONCLUSIONS

The closest to vendor policy is the least total cost stock location policy for DLA hazardous items. On an annual basis the difference is $4.2 million.

Large storage space shortages exist for the flammable and corrosive classes.

Large storage space surplus exists for the low hazard and compressed gas classes.

The combined effect of space shortages and surplus is that DLA has a slight excess of hazardous storage space under the assumption of 25 percent reduction of inventory due to initiatives in that area.

The three depots (DDRV, DDOU, and DDMT) can accommodate the increased number of lines caused by funneling all hazardous material through these depots.

In the single site customer policy, there is a one million dollar increase ($66 to $67 million) in total costs over the original closest to customer policy.

Implementing any of the modifications to the three site restriction has a relatively minor impact on costs and operational measurements under either policy examined.

# SECTION 5
# RECOMMENDATION

A closest to vendor stock location policy be implemented for DLA's hazardous items once a feasible solution to the space shortages is obtained.

Since excess space exists in some categories and serious shortages in others, DLA should investigate the costs and benefits of converting the excess space into conforming storage for the categories experiencing shortages.

# APPENDIX A

# HAZARDOUS STORAGE AND WORKLOAD CAPACITIES

## HAZARDOUS STORAGE AND WORKLOAD CAPACITIES
## (in attainable/conforming cubic feet)

| | OGDEN | MEMPHIS | RICHMOND |
|---|---|---|---|
| A RADIOACTIVE | 6,508 | 100 | 0 |
| C CORROSIVE | 839,385 | 229,975 | 257,152 |
| D OXIDIZER | 258,408 | 101,487* | 170,432 |
| E EXPLOSIVE | 6,508 | 0 | 0 |
| F FLAMMABLE | 477,361 | 335,051 | 166,992 |
| G GAS, COMP | 1,456,952 | 230,474+ | 823,032 |
| L LOW HAZARD | 4,882,770 | 0+ | 551,616 |
| P PEROXIDE | 6,508 | 0 | 116,288 |
| R REACTIVE | 40,821 | 0* | 53,256 |
| T POISON | 86,411 | 161,497 | 116,288 |
| TOTAL | 8,061,632 | 1,058,584 | 2,255,056 |
| GRAND TOTAL | | | 11,375,272 |
| DAILY THROUGHPUT IN MROS . . . . . . . | 300 | 325 | 475 |

* and +: Memphis combines these groups.

Figure A-1. Hazardous Storage and Workload Capacities

## APPENDIX B

## DLA HAZARDOUS STORAGE COMPATIBILITY CODE (HSCC) VS. DOD HAZARDOUS CHARACTERISTIC CODE (HCC)

COMPARISON TABLE
DLA HAZARDOUS STORAGE COMPATIBILITY CODE (HSCC)
VS. DOD HAZARDOUS CHARACTERISTIC CODE (HCC)

| HSCC | HCC | FACTORS TO CONSIDER |
|---|---|---|
| A1 | A1,A2,A3,A4 | ISOTOPE |
| E1 | E1,E2 | |
| E2 | E1,E2 | |
| E3 | E1,E2 | |
| S1 | ? | |
| P1 | T4,T5,F5 | IF IATA PACKAGING GROUP III, THEN T4 |
| P2 | T4,T5,F5 | IF IATA PACKAGING GROUP III, THEN T4 |
| G1 | G8 | |
| G2 | G2 | |
| G3 | G1 | |
| G4 | G3 | |
| G5 | G7 | |
| G6 | G4 | |
| G7 | G2 | |
| F1 | F2,F3,J1 | SIZE & FLASH POINT |
| F2 | F2,F3,J1 | SIZE & FLASH POINT |
| F3 | F4,J1 | SIZE & FLASH POINT |
| F4 | F4,J1 | SIZE & FLASH POINT |
| F5 | F4,F8,J1 | SIZE & FLASH POINT |
| F6 | N1 | FLASH POINT |
| C1 | C1,J6 | SIZE |
| C2 | C1,J6 | SIZE |
| B1 | C2,J6 | SIZE |
| B2 | C2,J6 | SIZE |
| R1 | D1,J3 | SIZE |
| R2 | ? | |
| R3 | R1 | |
| R4 | F7,J2 | SIZE |
| T1 | T7 | |
| T2 | J7 | |
| T3 | T2,T3 | IATA PACKAGING GROUP |
| T4 | T6 (MAYBE) | INFO ON MSDS |
| T5 | K1 | |
| J1 | J7 | |
| L1 | N1,C3,C4 | pH FOR C3 AND C4 |
| L2 | T4,J5 | IF IT IS IATA PACKAGING GROUP III |
| L3 | C1,C2 | IF IT IS ORM-B BY DOT |
| L4 | ? | |
| L5 | F1 | |
| L6 | J7 | |
| M1 | M1 | |
| N1 | N1 | |

? = Exact conversion unknown since HSCC could potentially go to more than one HCC. Need to look at data on an individual basis.

Table B-1. DLA Hazardous Storage Compatibility Code (HSCC) vs. DoD Hazardous Characteristic Code (HCC)

HAZARD CHARACTERISTIC CODES
RECOMMENDED HIERARCHY

| | | |
|---|---|---|
| 1. | E1 | EXPLOSIVE, MILITARY |
| 2. | E2 | EXPLOSIVE, LOW RISK |
| 3. | A1 | RADIOACTIVE MATERIAL, LICENSABLE |
| 4. | A2 | RADIOACTIVE MATERIAL, LICENSABLE LOW RISK |
| 5. | G8 | GAS, POISON, FLAMMABLE |
| 6. | G1 | GAS, POISON |
| 7. | T1 | DOT POISON INHALATION HAZARD |
| 8. | G9 | GAS, NONFLAMMABLE, POISON, CORROSIVE, OXIDIZER |
| 9. | G6 | GAS, NONFLAMMABLE, POISON, CORROSIVE |
| 10. | G7 | GAS, NONFLAMMABLE, POISON, OXIDIZER |
| 11. | G2 | GAS, FLAMMABLE, NON TOXIC |
| 12. | G5 | GAS, NONFLAMMABLE, CORROSIVE |
| 13. | F5 | FLAMMABLE AND POISON LIQUID |
| 14. | F6 | FLAMMABLE CORROSIVE LIQUID |
| 15. | F2 | FLAMMABLE LIQUID, IMDG 3.1 |
| 16. | F3 | FLAMMABLE LIQUID, IMDG 3.2 |
| 17. | G4 | GAS, NONFLAMMABLE, OXIDIZER |
| 18. | G3 | GAS, NONFLAMMABLE, NONTOXIC |
| 19. | T2 | UN POISON, PACKING GROUP I |
| 20. | D3 | OXIDIZER AND POISON |
| 21. | D4 | OXIDIZER AND CORROSIVE |
| 22. | D1 | OXIDIZER |
| 23. | P1 | PEROXIDE, ORGANIC, REGULATED |
| 24. | R1 | REACTIVE CHEMICAL, FLAMMABLE |
| 25. | R2 | WATER REACTIVE CHEMICAL |
| 26. | F7 | FLAMMABLE SOLID |
| 27. | C1 | CORROSIVE ACID, DOT REGULATED |
| 28. | C2 | CORROSIVE ALKALI, DOT REGULATED |
| 29. | F4 | FLAMMABLE LIQUID, IMDG 3.3 |
| 30. | F8 | COMBUSTIBLE LIQUID |
| 31. | T3 | UN POISON PACKING GROUP II |
| 32. | T4 | POISON, FOOD CONTAMINANT (UN PAK GP III) |
| 33. | T5 | PESTICIDE, LOW RISK |
| 34. | A3 | RADIOACTIVE MATERIAL, EXEMPT |
| 35. | A4 | RADIOACTIVE MATERIAL, EXEMPT AUTHORIZED |
| 36. | T6 | HEALTH HAZARD |
| 37. | T7 | CARCINOGEN |
| 38. | K1 | INFECTIOUS SUBSTANCE |
| 39. | K2 | CYCLOTOXIC DRUGS |
| 40. | C3 | ACID, LOW RISK |
| 41. | C4 | ALKALI, LOW RISK |
| 42. | D2 | OXIDIZER, LOW RISK |
| 43. | P2 | PEROXIDE, ORGANIC, LOW RISK |
| 44. | F1 | FLAMMABLE AEROSOL |
| 45. | J1 | MISCELLANEOUS FLAMMABLE LIQUIDS |
| 46. | J2 | MISCELLANEOUS FLAMMABLE SOLIDS |
| 47. | J3 | MISCELLANEOUS OXIDIZERS |
| 48. | J4 | MISCELLANEOUS ORGANIC PEROXIDES |
| 49. | J6 | MISCELLANEOUS CORROSIVES |
| 50. | J5 | MISCELLANEOUS POISONS |
| 51. | J7 | MISCELLANEOUS UN CLASS 9 |
| 52. | J8 | MISCELLANEOUS ORM-E |
| 53. | W1 | MARINE POLLUTANT |
| 54. | M1 | MAGNETIZED MATERIAL |
| 55. | N1 | NONHAZARDOUS |

NOTE: This hierarchy is a technical recommendation of DGSC-SSH as it applies only to storage pattern studies performed by DLA/DORO. The order was determined by considering those categories that could affect a large area or population in the event of an accident. Those that are more localized are generally listed next and those that are less hazardous are listed last.

Table B-2. Hazard Characteristic Codes Recommended Hierarchy

# APPENDIX C

## THE INDIVIDUAL HM DEPOTS
## A COMPARISON OF STORAGE SPACE OVER/(SHORT)
## AT 50 TO 75 PERCENT OF TOTAL SPACE

## THE INDIVIDUAL HM DEPOTS
## A COMPARISON OF STORAGE SPACE OVER/(SHORT)
## AT 50 AND 75 PERCENT OF TOTAL SPACE

| HAZARDOUS STORAGE FACILITY | AVERAGE STOCK IN CUBIC FEET | TOTAL CUBIC FEET AVAILABLE | CUBIC FEET OVER/(SHORT) AT 50% | CUBIC FEET OVER/(SHORT) AT 75% |
|---|---|---|---|---|
| OGDEN | | | | |
| RADIOACTIVE | 2,349 | 6,508 | 905 | 2,532 |
| CORROSIVE | 16,653 | 839,385 | 403,040 | 612,886 |
| OXIDIZER | 6,920 | 258,408 | 122,284 | 186,886 |
| EXPLOSIVE | 30 | 6,508 | 3,224 | 4,851 |
| FLAMMABLE | 28,149 | 477,361 | 210,532 | 329,872 |
| COMPRESSED GAS | 1,243 | 1,456,952 | 727,233 | 1,091,471 |
| LOW HAZARD | 3,082 | 4,882,770 | 2,438,303 | 3,658,996 |
| PEROXIDE | 11,904 | 6,508 | (8,650) | (7,023) |
| REACTIVE | 433 | 40,821 | 19,978 | 30,183 |
| POISON | 21,893 | 86,411 | 21,313 | 42,915 |
| TOTAL | 92,656 | 8,061,632 | 3,938,160 | 5,953,568 |
| MEMPHIS | | | | |
| RADIOACTIVE | 81,917 | 100 | (81,867) | (81,842) |
| CORROSIVE | 804,292 | 229,975 | (689,305) | (631,811) |
| OXIDIZER | 20,610 | 101,487 | 30,134 | 55,505 |
| EXPLOSIVE | 0 | 0 | 0 | 0 |
| FLAMMABLE | 230,685 | 335,051 | (63,160) | 20,603 |
| COMPRESSED GAS | 170,251 | 230,474 | (55,014) | 2,605 |
| LOW HAZARD | 0 | 0 | 0 | 0 |
| PEROXIDE | 0 | 0 | 0 | 0 |
| REACTIVE | 0 | 0 | 0 | 0 |
| POISON | 71,633 | 161,497 | 9,116 | 49,490 |
| TOTAL | 1,379,388 | 1,058,584 | (850,096) | (585,450) |
| RICHMOND | | | | |
| RADIOACTIVE | 0 | 0 | 0 | 0 |
| CORROSIVE | 1,059,004 | 257,152 | (930,428) | (866,140) |
| OXIDIZER | 20,925 | 170,432 | 64,291 | 106,899 |
| EXPLOSIVE | 0 | 0 | 0 | 0 |
| FLAMMABLE | 1,921,925 | 166,992 | (1,838,429) | (1,796,681) |
| COMPRESSED GAS | 199,727 | 823,032 | 211,789 | 417,547 |
| LOW HAZARD | 53,730 | 551,616 | 222,078 | 359,982 |
| PEROXIDE | 5,470 | 116,288 | 52,674 | 81,746 |
| REACTIVE | 107,270 | 53,256 | (80,642) | (67,328) |
| POISON | 316,918 | 116,288 | (258,774) | (229,702) |
| TOTAL | 3,684,969 | 2,255,056 | (2,557,441) | (1,993,677) |

Table C-1. The Individual HM Depots